Method and device for producing foamed synthetic webs

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Abstract

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method and device for producing Foamed Synthetic Webs

I, GUNTHER MISSBACH, a German National, of Essen-Werden, Heckstrasse 101, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method and to devices for producing foamed synthetic webs, for example foamed polystyrene webs, using extruders and starting from granulated material, as is customary in plant of this kind, and transforming the latter into web during the process and controlling the forming effect peculiar to the production of foamed webs by means of foaming agents included in the stock and becoming operative in the devices connected behind the extruding nozzle.

Conventional methods and apparatus of the type referred to provide for the web to emerge into the open immediately after leaving the ring or slot nozzle. However, since the foaming process at that time has not yet been completed, the web has the tendency of continuing its expansion in all three dimensions when leaving the extruder nozzle, such expansion being increased by the fact that the expansion of the web is suddenly no longer restricted by the confines of the orifice.

Owing to this sudden expansion, creases will usually appear at points where the web, hitherto restricted within the orifice, is now allowed to expand to a larger dimension.

This happens with slot orifices as well as with ring orifices. The result in both cases is that, for example when an extruder with ring orifice is employed, streaks appear in the region of the creases during the customary subsequent inflation of the tube.

Careful examination of this streak structure has revealed that the web in these regions has a structure differing from other zones in that here the unit weight is greater and the behaviour of the web during further processing is in many respects less favourable.

This phenomenon can be explained by the fact that the web in the "troughs" of the several creases cools more slowly and is therefore subject to a foaming effect different to that in the "crest" zones of the web. The reason for this is that in known processes:

a) the "crest" regions, after leaving the nozzle, are suddenly and prematurely exposed *externally* to the lower ambient temperature and therefore cool quickly, whereas on the other hand

b) the "trough" regions are heated internally by the hotter air injected for the purpose of inflation, so that

c) the web is compressed in the "troughs" — a process directly contravening the intended inflation, and

d) the larger web volume present in the "troughs" conserves the heat stored during extrusion for a period longer than the smaller web volume present in the "crest."

It is true that, during the subsequent process of inflation, the web is gradually smoothed because the creases are pulled apart and vanish, but the previously produced differences of structure cannot thereby be eliminated. Longitudinal streaks of different colouring — i.e. light and dark streaks — are produced which, during the later phase of continued forming of the web in unrestricted space, do not behave as they should in that they foam less strongly than the other web regions, so that the final product varies in thickness and exhibits corrugations and irregularities. Also the weight per unit of volume in the various zones, and therefore the insulating strength against cold and heat, as well as stability and deformability vary for the same reason.

It is true that the above-mentioned thickness variations can be avoided in that the web is profiled or gauged in the course of a subsequent special (i.e. additional) processing stage, such that its total expansion is restricted to the amount governed by the expansion capacity of the streaked zones. But this introduces

the disadvantage that the other zones cannot expand fully and the volume expansion capacity inherent in the material cannot be exploited to the full. Thus, structural variations in the various zones, with all their attendant disadvantages, are not changed at all by this kind of after-treatment. This fact is of great disadvantage during moulding operations, and especially in vacuum deep drawing of foamed webs.

According to the present invention a method of producing a foamed synthetic web includes the step of extruding the material through a nozzle having an expansion section whose cross-section transverse to the direction of material flow is smoothly flared along the said direction so that the web emerges from the nozzle only when the foaming process is substantially complete in all three dimensions.

The web is thus enabled to increase in thickness and also in width or diameter according to whether a slot nozzle or an annular nozzle respectively is coupled. The extent of lengthwise expansion of the web can be controlled within wide limits by regulating the draw-off speed of the web.

Preferably, the expansion takes place with the application of heat.

The dimensions of the expansion section are governed by the contemplated final thickness and width (or diameter) of the web and must be related to the properties of the material being extruded.

In order to avoid using different nozzles for different purposes, and also in order to be able to vary the shape of the expansion section during operation with a view to obtaining optimum operating conditions quickly when the plant is started, means are provided for controlling and continuously varying the web dimensions during manufacture. This may be achieved in the case of an annular nozzle by arranging that an inner core of the nozzle is arranged to be displaceable in the direction of its longitudinal axis and is coupled for longitudinal motion together with the extruder screw.

When the synthetic material is extruded in the form of a tube which is inflated after leaving the nozzle of the extruder the outlet end of the nozzle passage may be inclined so that the web leaves the nozzle at such an angle that its direction of exit is substantially the same as the inclination of the base of the inflated portion of the tube.

The present invention, moreover, offers the possibility to dispense with the conventional inflation of the tubular web leaving the extruder, i.e. with a process required in order to achieve the desired web width. It is well known that the web is stretched during inflation, whereas, on the other hand, every effort is made in the manufacture of foamed web to produce a web of maximum thickness and minimum weight per unit of volume, so that the web should acquire the best possible properties for packing and insulating purposes. Moreover, large pores and thus a small proportion of material are desired, so as to achieve a favourable cost factor per unit of area. Inflation taking place immediately behind the extruder is however directly opposed to the above-mentioned aims.

According to prior art, the web is subjected to after-treatment with varying temperature and varying external pressure, with a view to achieving the above objects. This after-treatment can be largely avoided according to the present invention if the expansion process in the extruder or in the expansion section provided by the present invention is taken as far as possible. One manner of performing the present invention achieves the above-mentioned object, i.e. avoids the inflation of the web, by splitting the tubular web as it leaves the nozzle, for example by means of fixed or revolving knives, into two or more longitudinal webs, each tubular web portion being subsequently led separately to further processing stations.

In this arrangement, each strip is gradually opened out as it is drawn from the extruder and is subsequently deformed into a flat web. Each strip may be gradually flattened by being led over a corresponding deflection roller. During the deformation into a flat form, the width of the web increases constantly without the necessity for inflation as previously used. The margins of the web may be trimmed after passing over the rollers to produce a web of even width. The strips cut on both sides during this process are either wound up or immediately fed to a container where they are crushed and subsequently added partly to the granulated material again. The further the two circular knives are spaced from the web exit, i.e. from the nozzle the wider the web. The latter is either wound or, if it is too thick to be wound, cut into sheets or led to further processing stations, for example to be moulded by vacuum or positive air pressure. Further details of the invention will now be explained with reference to the accompanying drawings in which apparatus for carrying out the new method are illustrated by contrast with conventional devices. In the drawings:

Figs. 1 and 2 represent diagrammatically a conventional apparatus for producing foamed synthetic web, Fig. 1 showing the ring nozzle of an extruder in longitudinal section, with a tubular web leaving the nozzle exit, and

Fig. 2 showing a cross section of the tubular web and illustrating the crease formation characteristic for this type of apparatus.

Fig. 3 illustrates one embodiment of apparatus according to the invention, shown diagrammatically in longitudinal section;

Fig. 4 illustrates diagrammatically another embodiment of the invention in plan, showing a tubular web leaving the ring nozzle in cone

formation, the two circular knives splitting the tube for example into two halves, and the further progress of the tubular web which is gradually opened out into a flat web, is trimmed laterally and further advanced in the shape of a web over deflection rollers; and

Fig. 5 is a side elevation of the apparatus shown in Fig. 4.

As shown in Figs. 1 and 2, the web 1 in a conventional apparatus leaves the ring nozzle of the extruder which consists of an outer component 2 and a core 3. It tends to expand immediately, so that creases are produced as shown at 3*a* to enable the web to accommodate the sudden increase in width.

The embodiment illustrated in Fig. 3 which discloses the basic principle of the invention, comprises a screw 4 which urges the tube-like structure produced from the granulated material into a cylindrical bore defined in the ring nozzle section 6, 7. From there it does not pass into free space, but into a heated expansion section 7*a* of the nozzle where it can expand without restriction in all three dimensions, and then emerges without noticable transitions into free space, so that its direction of exit is substantially the same as the inclination of the base of the tubular shape 9*b*, produced at 9*a* by inflation. Thus, non-uniform behaviour of the tubular web is completely avoided. To enable the dimensions of the expansion section 7*a* to be continuously varied during operation, the core 7, 9 is arranged so as to be longitudinally displaceable relative to the annular components 6, 8 and is coupled by means of the intermediate component 10*a* and axial bearings 10*b* to the extruder screw 4. The longitudinal displaceability of the screw 4, customary in extruders, therefore also makes possible the desired displacement of the cores 7 and 9, and thus a variation of the channel width for guiding the web, of the web thickness and, furthermore, of the tube diameter.

In the embodiment illustrated in Figs. 4 and 5, the tubular web 5 passes from the cylindrical portion 6 of the ring nozzle of the extruder, into the expansion section devised substantially as illustrated in Fig. 3 and indicated therein at 8, 9, and then emerges into the open. During this process, the tubular web 5 is split into two halves 13, 14 by means of the circular knives 11, 12. The two halves of the tube move in the directions indicated by arrows 15, 16, 17. The left and right cutting edges of the half portion of the tubular web, on the other hand, move in the directions indicated by arrows 18, 19.

Each half of the tube is gradually opened out, so that when it reaches the deflection roller 20 it is already flat and is fed to the deflection roller 22 as a plane web travelling in the direction of arrow 21.

On its way from the deflection roller 20 to the deflection roller 22 the web is laterally trimmed by further circular knives 23, 24, so that the marginal waste strips 25, 26 are produced. Fig. 4 shows how the marginal strip 26 proceeds to a container 27, from there to be conducted for example to a crushing mill, not shown here. In this way, a certain proportion of the marginal strips 25, 26, can again be admixed to the granulated material. It would also be possible to wind the marginal strips 25, 26, in order to be able to prepare them in a convenient, space-saving manner for further processing while in this condition. The finished trimmed web 28 is advanced for further use in the direction of arrow 29.

WHAT I CLAIM IS:—

1. A method of producing a foamed synthetic web which includes the step of extruding the material through a nozzle having an expansion section whose cross-section transverse to the direction of material flow is smoothly flared along the said direction so that the web emerges from the nozzle only when the foaming process is substantially complete in all three dimensions.

2. A method as claimed in Claim 1 in which the expansion takes place with the application of heat.

3. A method as claimed in Claim 1 or Claim 2 in which means are provided for controlling and continuously varying the web dimensions during manufacture.

4. A method as claimed in any one of Claims 1—3 in which the synthetic material is extruded in the form of a tube which is inflated after leaving the nozzle and in which the outlet end of the nozzle passage is inclined so that the web leaves the nozzle at such an angle that its direction of exit is substantially the same as the inclination of the base of the inflated portion of the tube.

5. A method as claimed in any one of Claims 1—3 in which the synthetic material is extruded as a tube which is longitudinally slit into two or more strips as it leaves the nozzle.

6. A method as claimed in Claim 5 in which each strip is gradually opened out as it is drawn from the extruder and is subsequently deformed into a flat web.

7. A method as claimed in Claim 6 in which the margins of the flat web are trimmed.

8. An extruder for carrying out the method claimed in any one of Claims 1—7 in which an extruder nozzle includes an expansion section whose cross-section transverse to the direction of material flow is smoothly flared along the latter direction.

9. An extruder as claimed in Claim 8 in which the nozzle is annular and has its inner core arranged so as to be displaceable in the direction of its longitudinal axis and is coupled for longitudinal motion together with the extruder screw.

10. An extruder as claimed in Claim 8 or 9, for the extrusion of inflated webs in which the nozzle is annular, and in which the outlet

end f the nozzle passage is inclined so that in use the web leaves the nozzle at such an angle that its direction of exit is substantially the same as the inclination of the base of the inflated portion of the tube.

11. An extruder as claimed in any one of Claims 8 or Claim 9 for carrying out the method as claimed in any one of Claims 5—7 including two or more knives positioned to split the tubular web into two or more strips as it leaves the nozzle.

12. An extruder as claimed in Claim 11 in which a deflection roller is provided corresponding to each strip so that in use the strip is gradually flattened as it approaches the corresponding deflection roller.

13. An extruder as claimed in Claim 11 in which two further knives are associated with each of the deflection rollers to trim the margins of the corresponding strip after it has past over the roller.

14. A method of producing a foamed synthetic web substantially as hereinbefore described.

15. An extruder for producing a foamed synthetic web substantially as hereinbefore described with reference to Figure 3 or Figures 4 and 5 of the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

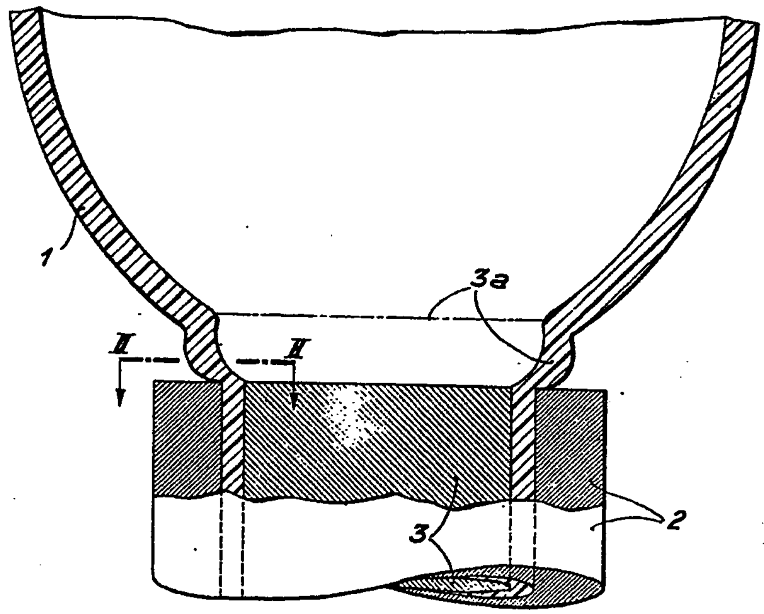


Fig. 2

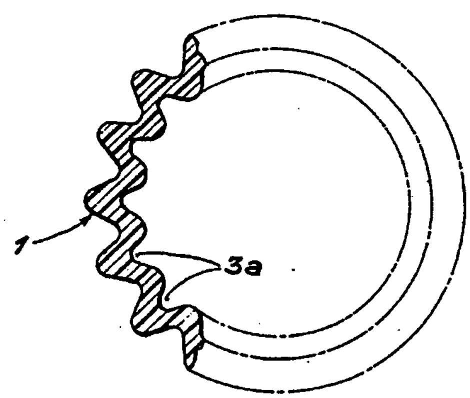
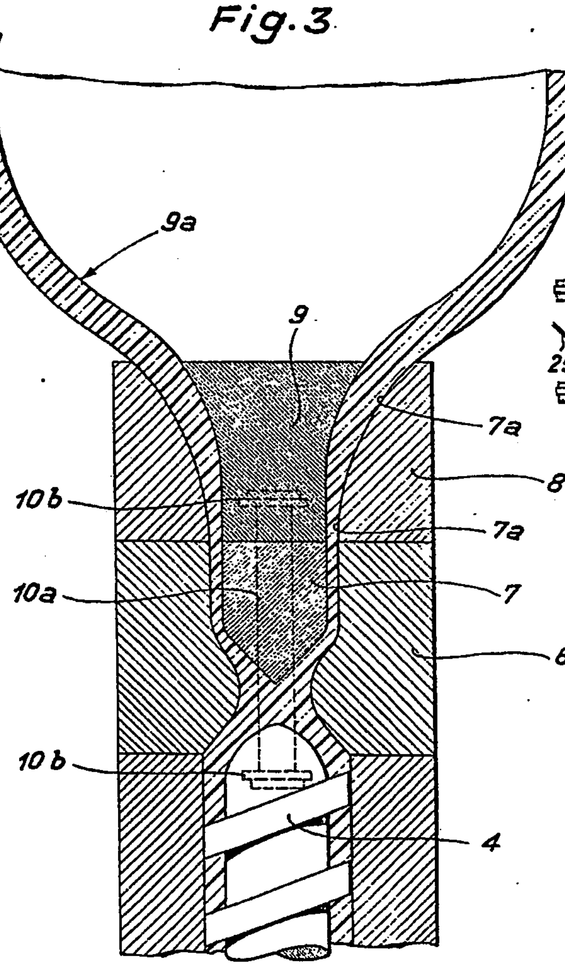


Fig. 3



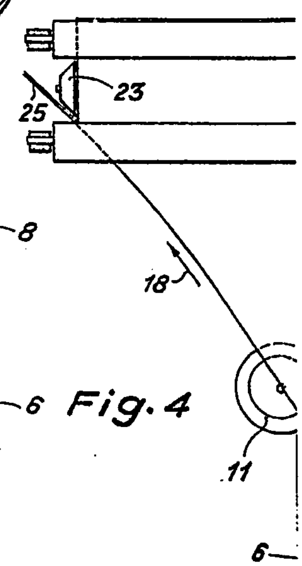
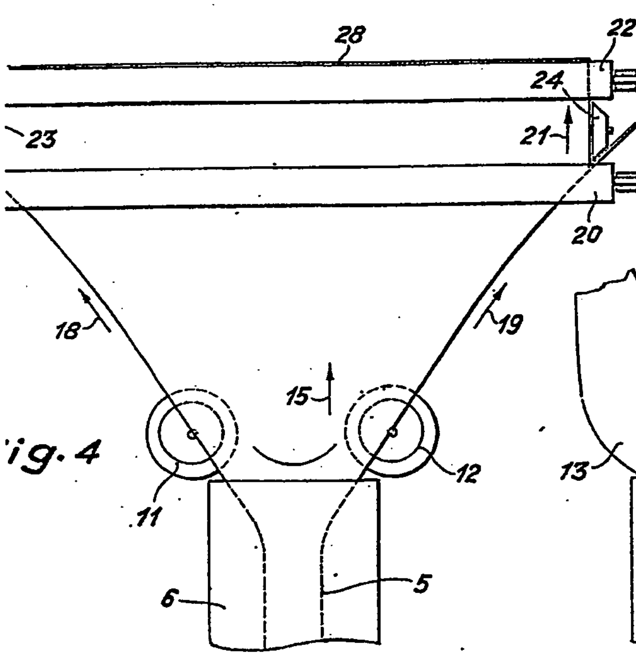


Fig. 4

1075474 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2



ig. 4

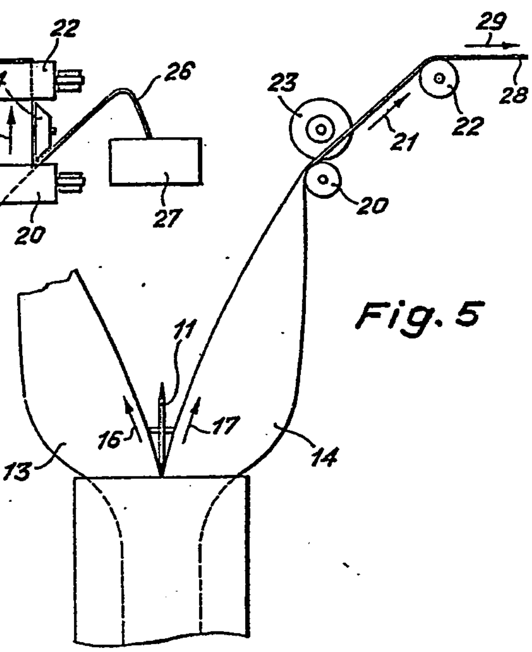


Fig. 5

1075474 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

Fig. 3

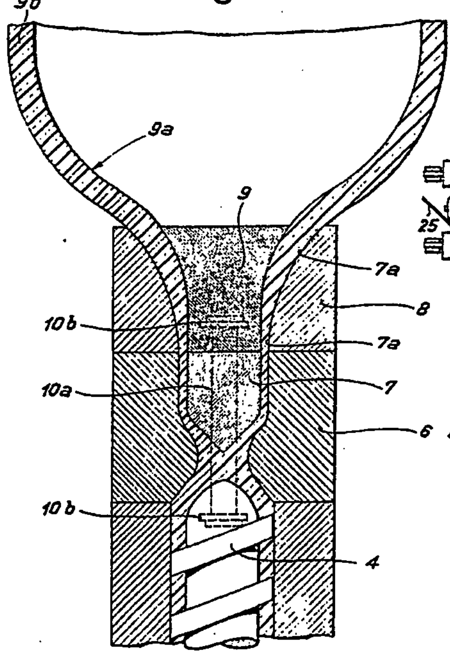


Fig. 4

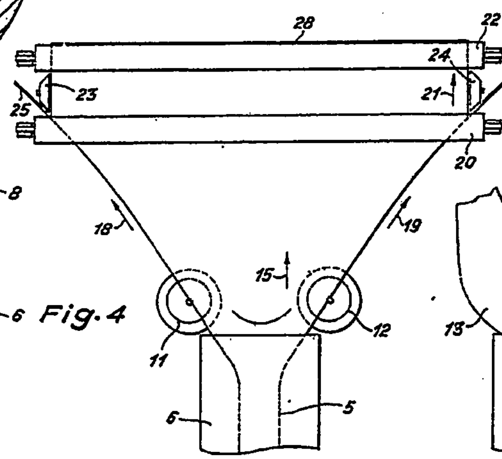


Fig. 5